AERMOD Modeling Analysis of the 1-Hour Sulfur Dioxide Impacts Due to Emissions from the Portland Generating Station

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Bureau of Technical Services
Division of Air Quality
New Jersey Dept. of Environmental Protection

Introduction

This report is an addendum to and supplements the results of the previous CALPUFF modeling analyses submitted in support of New Jersey's May 12, 2010 Section 126 petition to the Environmental Protection Agency (EPA). The final rule for the new 1-hour primary National Ambient Air Quality Standard (NAAQS) for sulfur dioxide (SO_2) was promulgated June 2, 2010 (75 Fed. Reg. 39,633 (July 12, 2010)) and becomes effective August 23, 2010. This report describes a modeling study that predicted the 1-hour SO_2 concentrations, based on emissions from the Portland Generating Station in Northampton County, Pennsylvania, in a large area centered on the Portland plant. Only the emissions from the Portland Generating Station were included.

The predicted AERMOD concentrations were compared with the new 1-hour SO_2 NAAQS of 196 ug/m^3. Predicted impacts were also compared to the 3-hour SO_2 NAAQS of 1,300 ug/m^3. The modeling study utilized meteorological tower and Doppler SODAR data collected 2.3 km west of the facility between July 1993 and June 1994. The meteorological database and one of the receptor grids used in this study were also used in the 1999 Warren County Air Quality Compliance Study. This earlier modeling of the Portland Generating Station is described in the document *SO_2 NAAQS Compliance Modeling for GPU's Portland Generating Station* (ENSR, 1999).

Modeling Platform

The New Jersey Department of Environmental Protection (NJDEP), Bureau of Technical Services (BTS), performed modeling of the Portland Generating Plant with the latest EPA approved version of the AERMOD modeling suite; AERMOD (version 09292), AERMAP (version 09040), and AERMET (version 06341).

Meteorology

Meteorological measurements were taken at a site located 2.3 km west-southwest of the Unit 1 and 2 stacks at an elevation of 610 ft above mean sea-level (amsl). Measurements from a 100 meter meteorological tower and a SODAR were collected from July 1, 1993 through June 30, 1994. The 100-meter tower measurements consisted of hourly values of solar radiation and multiple levels of wind direction (30 m and 100 m), wind speed (10m, 30m and 100m), and temperature (2m, 10m, 30m, 70m, and 100m). In addition, turbulence measurements of the standard deviation of horizontal wind direction (sigma-theta) were taken at 10m, 30m and 100m. The standard deviation of the vertical wind velocity (sigma-w) was measured at 30m and 100m.

The SODAR data provided wind speed and wind direction measurements at 14 levels, from 120m to 510m above ground at 30m increments.

Processing of Meteorological Data for AERMOD

Site characteristics such as surface roughness, albedo, and Bowen ratio in the original analysis were recalculated using updated EPA guidance concerning the area over which these values are calculated.

Also, review of the earlier AERMOD modeling of the Portland Generating Station (ENSR, 1999) found that incorrect coordinates were used to calculate the surface characteristics for input into AERMET. The land use parameters input into AERSURFACE were centered at the approximate location of the Portland stacks, not the meteorological station. This error was corrected.

AERSURFACE (version 08009) was used to determine the surface roughness, albedo and Bowen ration for the area surrounding the meteorological station. Landover in the area was based on the 1992 USGS National Land Cover Data Sets (NLCD92). Surface roughness was calculated for 12 sectors extending out 2 km from the meteorological tower. The default radius for surface roughness of 1 km was not used because the lowest height of wind speed input, 30 m, was well above the 10 m height used as the basis for the 1 km recommendation. The AERMOD Implementation Guide, Section 3.1.2 states: "Exceptions to the recommended default distance of 1 km for surface roughness may be considered on a case-by-case basis for applications involving site-specific wind measurements taken at heights well above 10 m" (EPA, 2009). The AERMOD Implementation Guide is available at: www.epa.gov/ttn/scram/7thconf/aermod/aermod_implmtn_guide_19March2009.pdf.

The Bowen ratio and albedo were based on the average characteristics over a 10 by 10 km square centered on the observing site. The Bowen ratio was determined on a monthly basis and the characterization of a month's precipitation as wet or dry was based on climatological data from Allentown PA. All months were considered to have average precipitation.

The meteorological data were processed with the AERMET meteorological preprocessor (version 06341) to provide the "surface" meteorological data file for input into AERMOD. The local meteorological data was supplemented by surface measurements taken at the Allentown PA NWS station and the Albany NY upper air sounding data.

Processing of the Terrain Data

Terrain data used in AERMAP (version 09040) included sixteen 7.5 minute (1:24,000) USGS digital elevation model (DEM) data. These 16 files of 7.5 minute DEM data was centered on the Portland Power Plant and provided terrain height information every 10 m horizontally. Because some of the receptors in the largest receptor grid used were not covered by the sixteen 7.5 minute DEM data, four additional 1 degree (1:192,000) DEM files were also input into AERMAP. These 1 degree DEM files provide terrain height information every 30 m horizontally. The elevation of each receptor and its hill height scale were calculated by AERMAP. Figure 1 shows the terrain relief in the vicinity of the Portland Generating Station.

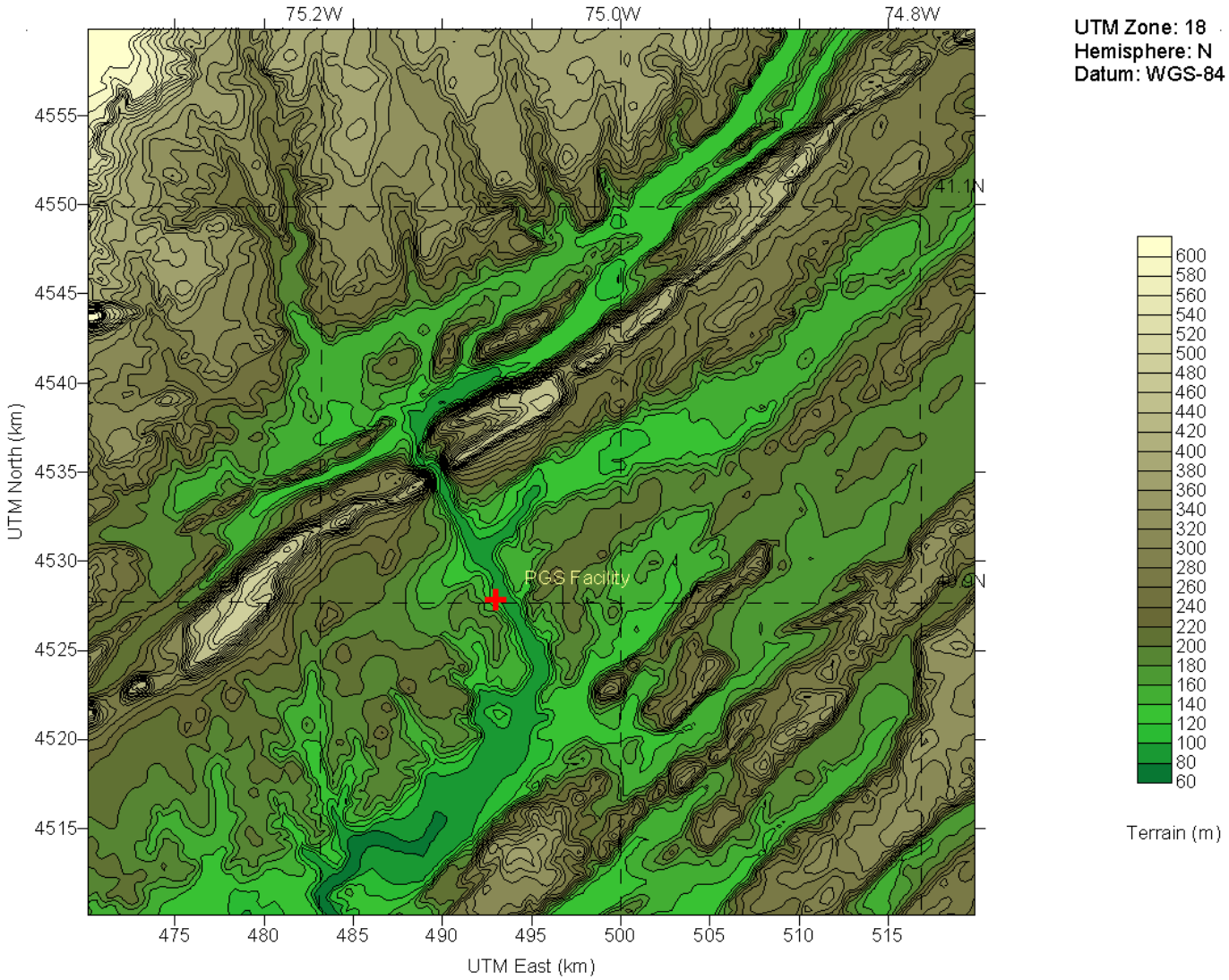

Figure 1 Terrain in the vicinity of the Portland Generating Station

Figure 2 Receptor Locations

Receptor Grids

Receptor Grid #1 - Figure 2 shows the large receptor grid used in the initial modeling run. This receptor grid is identical to that used in the 1999 modeling study (ENSR, 1999). The receptor grid contained 5,189 receptors and consisted of the following 250 meter grids:

- a diagonal area of elevated terrain encompassing the Kittatinny Ridge areas in both Pennsylvania and New Jersey,
- a square area 6 km on a side, centered at the Portland site, and
- a diagonal area of elevated terrain to the northeast of the Jenny Jump terrain.

Receptor Grid #2- Based on the modeling results from use of Receptor Grid #1, the location where maximum 1-hour impacts occurred was identified. An additional fine receptor grid with 100 meter spacing over a 1 km by 1 km area was placed at the location of the maximum impact.

Receptor Grid #3- An additional large grid with uniform receptor spacing was used for purposes of generating a figure showing the spatial extent of the area where the 1-hour SO_2 NAAQS was predicted to be violated by AERMOD. This modeling grid extended 32 km in the east-west direction (UTMs 483.000 km to 515.000 km) and 40 km in the north-south direction (4513.000 km to 4553.000 km). The receptor spacing in this grid was 500 m. The total number of receptors was 5,265.

Stack Parameters

Stack parameters modeled are listed in Table 1. These stack parameters were taken from data sets on a CD submitted by the owner of Portland Power Plant (currently RRI Energy Mid-Atlantic Power Holdings LLC ("RRI Energy")) entitled "Dispersion Modeling File Archive Revised NAAQS and PSD Increment for SO_2 and PM-10" (July 2001).

Table 1. Stack Parameters

Source	UTM Coordinates [a]		Stk. Base (ft amsl)	Stack Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Temp. (K)
	X (km)	Y (km)					
Unit 1	493.349	4528.506	294	121.9	2.84	43.3	403.1
Unit 2	493.335	4528.554	294	121.9	3.79	36.26	405.9

a. NAD27

Allowable Sulfur Dioxide Emissions

The hourly SO_2 emission rates for Units 1 and 2, which were used in the modeling, were based on the allowable limits of 8.73 tons per 3-hours for Unit 1 and 13.35 tons per 3-hours for Unit 2 (based on Title V operating permit for Portland Generating Station). The emission rates are listed in Table 2. These hourly allowable emission rates correspond to 3.51 lbs of SO_2/MMBtu for Unit 1 (assuming a maximum heat input of 1657.2 MMBtu/hr) and 3.54 lbs of SO_2/MMBtu for Unit 2 (assuming a maximum heat input of 2511.6 MMBtu/hr).

Table 2. Portland Generating Station SO_2 Allowable Emission Rates

Unit	lb/hr
1	5,820
2	8,900

Estimate of Actual Sulfur Dioxide Emissions

Monthly actual SO_2 emission rates were obtained from data submitted in 2003 by RRI Energy in response to an EPA 114 letter (RRI Energy, 2003). The SO_2 emissions calculated for each month were uniformly distributed over each hour of that month. The total emissions from Unit 1 during the July 1993 to June 1994 period was 7,006 tons. The total SO_2 emissions from Unit 2 during this period was 14,630 tons. An emission factor of 36.1 lbs of SO_2 per ton of coal, the percent sulfur in the coal, and the amount of coal fired in the month were used to calculate the amount of sulfur dioxide emitted in a month.

Table 3. Portland Generating Station Unit 1 Actual SO_2 Monthly Emission Rates

Year	Month	Tons of Coal Fired	Sulfur Content of Coal (%)	Unit 1 SO_2 [a] (tons)	Unit 1 Avg. SO_2 (lbs/hr)	Percent of Allowable (5,820 lb/hr)
1993	JULY	32,599	2.17	1276.9	3432.2	0.59
1993	AUGUST	30,787	1.93	1072.5	2882.9	0.50
1993	SEPTEMBER	18,947	1.96	670.3	1862.0	0.32
1993	OCTOBER	0	1.84	0.0	0.0	0.00
1993	NOVEMBER	231	1.81	7.6	21.0	0.00
1993	DECEMBER	27,277	1.72	846.8	2276.3	0.39
1994	JANUARY	18,979	2	685.1	1841.7	0.32
1994	FEBRUARY	31,245	2.07	1167.4	3474.2	0.60
1994	MARCH	4,023	1.6	116.2	312.3	0.05
1994	APRIL	0	1.62	0.0	0.0	0.00
1994	MAY	4,474	1.89	152.6	410.3	0.07
1994	JUNE	31,800	1.76	1010.2	2806.2	0.48

a. emission rate = (tons of coal * % sulfur*36.1)/2000

Table 4. Portland Generating Station Unit 2 Actual SO_2 Monthly Emission Rates						
Year	Month	Tons of Coal Fired	Sulfur Content of Coal (%)	Unit 2 SO_2 [a] (tons)	Unit 2 Avg. SO_2 (lbs/hr)	Percent of Allowable (8,700 lb/hr)
1993	JULY	33,129	2.17	1297.6	3488.0	0.39
1993	AUGUST	41,505	1.93	1445.9	3886.5	0.44
1993	SEPTEMBER	32,489	1.96	1149.4	3192.8	0.36
1993	OCTOBER	32,586	1.84	1082.2	2909.1	0.33
1993	NOVEMBER	29,705	1.81	970.5	2695.8	0.30
1993	DECEMBER	35,485	1.72	1101.7	2961.3	0.33
1994	JANUARY	37,442	2	1351.7	3633.3	0.41
1994	FEBRUARY	34,813	2.07	1300.7	3871.0	0.43
1994	MARCH	43,277	1.6	1249.8	3359.6	0.38
1994	APRIL	25,745	1.62	752.8	2091.2	0.23
1994	MAY	47,904	1.89	1634.2	4392.8	0.49
1994	JUNE	40,727	1.76	1293.8	3594.0	0.40

a. emission rate = (tons of coal * % sulfur*36.1)/2000

Background SO_2 Concentrations

Background concentrations were not included in the analysis. All SO_2 impacts reported are exclusively due to the emissions from Portland Generating Station Units 1 and 2.

1-Hour Sulfur Dioxide Modeling Results

Allowable Emission Rates

The modeling conducted with Receptor Grid #1 predicted that the maximum 99th percentile (4th highest) daily 1-hour concentration occurs on Kittatinny Ridge in New Jersey just to the east of the Delaware River Water Gap. The more refined Receptor Grid #2 with 100 m spacing was placed at that location. The results of the Receptor Grid #2 modeling are given in Table 3. The maximum 1-hour SO_2 concentration predicted in the refined Receptor Grid #2 was 3700 ug/m^3. The maximum 99th percentile (4th highest) daily 1-hour concentration predicted was 1402 ug/m^3, over seven times the 1-hour SO_2 NAAQS of 196 ug/m^3. Within the fine grid, at a single receptor there was a maximum of 42 days in violation of the NAAQS and 46 days exceeding the NAAQS (i.e., at least one 1-hour concentration during the day above 196 ug/m^3).

Figure 3 displays the modeling results from Receptor Grid #3 and the area where the 1-hour SO_2 NAAQS violations are predicted. As can be seen, NAAQS violations due to Portland's emissions are predicted over large areas of Warren County NJ and extend north into Sussex County NJ. The figure indicates that violations of the 1-hour SO_2 NAAQS are predicted well beyond the 35 km by 40 km modeling grid to the south.

Table 5. Predicted 1-Hour Sulfur Dioxide Concentrations with Allowable Emissions [a, b]

Averaging time	Max. Predicted Impact (ug/m^3)	Max. Predicted 99th Percentile Impact (ug/m^3)	Maximum Number of Violation Days	NAAQS (ug/m^3)
1-hour	3700	**1,402** [b]	**42**	196

a. Only values in New Jersey listed.
b. Includes no SO_2 background concentrations.

The high and high, second-high 3-hour concentrations predicted within Receptor Grid #2 were 1,334 ug/m^3 and 909 ug/m^3, respectively. Because the high, second-high value is below 1,300 ug/m^3, no violation of the 3-hour SO_2 NAAQS is predicted.

Estimated Actual Emission Rates

The modeling conducted with the July 1993 through June 1994 actual emission rates may underestimate the current actual SO_2 concentrations in the vicinity of the Portland Power Plant for the following two reasons:

- Actual SO_2 emissions from the facility for the 12 month period from July 1, 1993 to June 30, 1994 were only 21,363 tons. This value is much lower than the 2007 – 2009 average actual emissions of 31,398 tons per year and is only 33 percent of the allowable emission rate

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- A stack gas exit temperature and stack gas exit velocity representative of 100 percent load was assumed. For the vast number of hours between July 1, 1993 to June 30, 1994, Units 1 and 2 were running below 100 percent load and, therefore, the stack gas exit temperature and stack gas exit velocity would be lower than assumed. If the actual stack gas exit temperature and stack gas exit velocity of Unit 1 and 2 were modeled, the resulting lower plume rises would have led to the prediction of higher SO_2concentrations.

The refined Receptor Grid #2 with 100 m spacing was placed at that location where the allowable emissions maximum occurred on Kittatinny Ridge in New Jersey. The results of the Receptor Grid #2 modeling are given in Table 6. The maximum 1-hour SO_2 concentration predicted in the refined Receptor Grid #2 was 1,713 ug/m^3. The maximum 99th percentile (4th highest) daily 1-hour concentration predicted was 467.3 ug/m^3, more than double the 1-hour NAAQS of 196 ug/m^3. Within the fine grid, at a single receptor there was a maximum of five days in violation of the NAAQS and nine days exceeding the NAAQS (i.e., at least one 1-hour concentrations during the day above 196 ug/m^3).

Figure 4 displays the modeling results when modeling the estimated actual emissions with Receptor Grid #3. Violations of the 1-hour SO_2 NAAQS violations are predicted on Kittatinny Ridge and on the elevated terrain approximately 2 km east of the Portland Power Plant.

Table 6. Predicted 1-Hour Sulfur Dioxide Concentrations with Estimated Actual Emissions [a, b]

Averaging time	Max. Predicted Impact (ug/m^3)	Max. Predicted 99th Percentile Impact (ug/m^3)	Maximum Number of Violation Days	NAAQS (ug/m^3)
1-hour	1,713	**467.3** [b]	**5**	196

a. Only values in New Jersey listed.
b. Includes no SO_2 background concentrations.

Conclusion

The current allowable short-term SO_2 emission rates at Portland Power Plant are 8.73 tons per 3-hour period (3.51 lbs of SO_2 per MMBtu) for Unit 1 and 13.35 tons per 3-hour period (3.54 lbs of SO_2 per MMBtu) for Unit 2. Based on the AERMOD modeling of 1-hour SO_2 impacts caused by Portland Power Plant, both units would need to reduce their allowable emission rates to approximately 0.5 lbs of SO_2 per MMBtu, an 86 percent reduction, in order to meet the new 1-hour SO_2 NAAQS in New Jersey.

References

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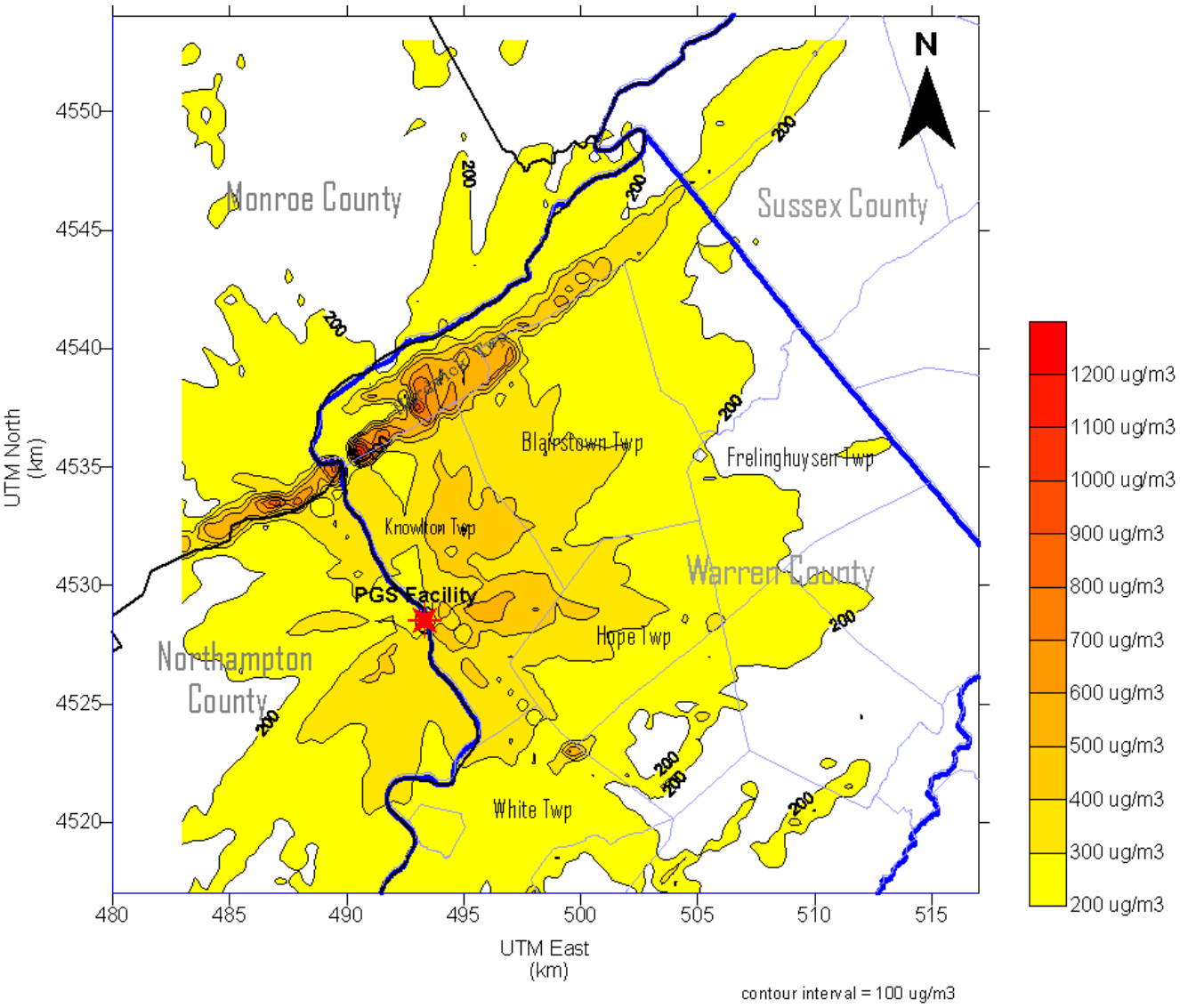

Figure 3. AERMOD Predictions of the 99th Percentile 1-Hour Sulfur Dioxide Impacts due to Allowable Emissions from the Portland Power Plant

1-Hour SO2 NAAQS of 196 ug/m^3
Includes no background concentrations
July 1993 - June 1994 meteorological data

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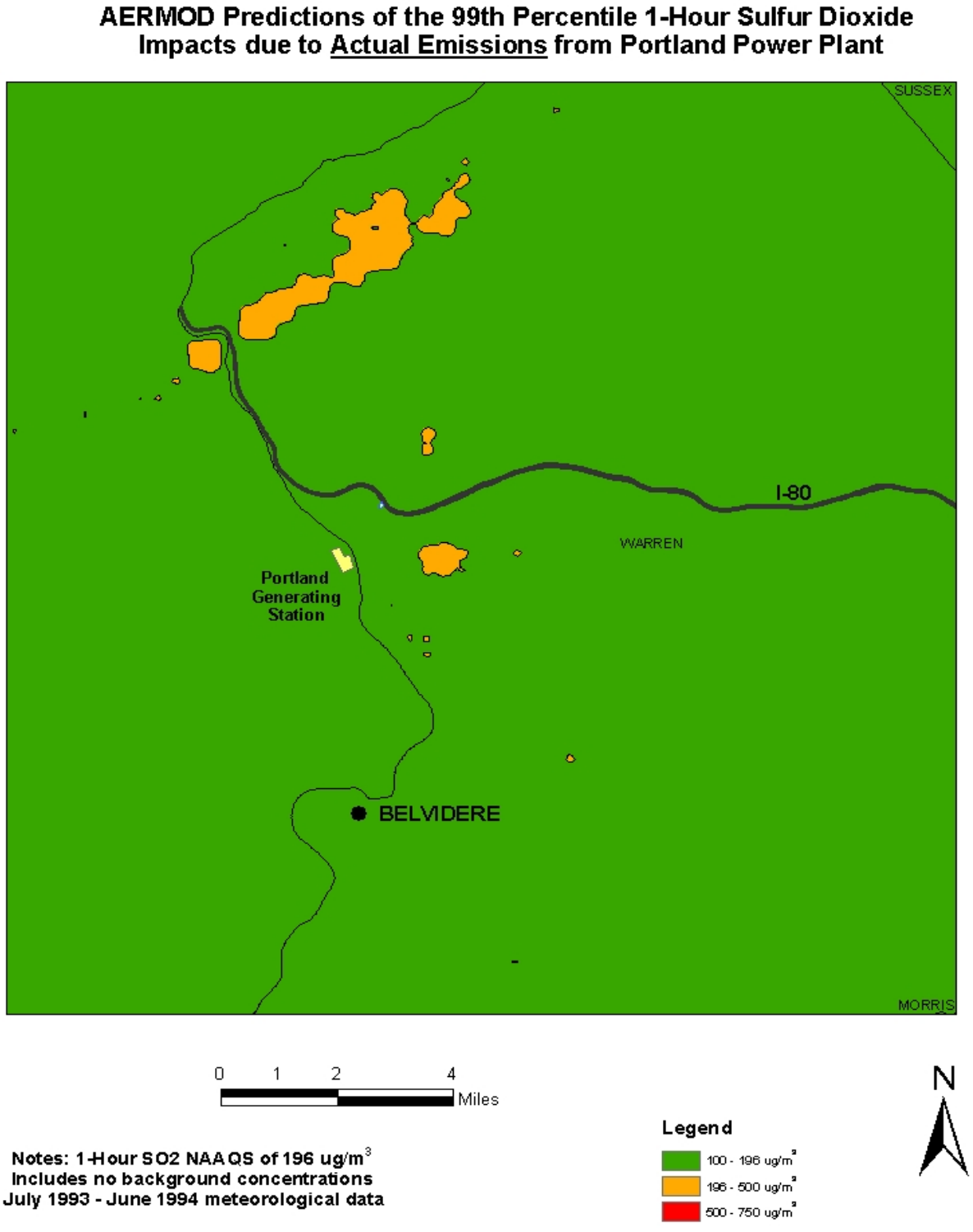

Figure 4. AERMOD Predictions of the 99th Percentile 1-Hour Sulfur Dioxide Impacts due to Actual Emissions from the Portland Power Plant